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Pallet truck selection with MEREC and WISP-S methods

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Abstract

Background: The article presents an MCDM model based on the MEREC and WISP-S methods for pallet truck selection.

Purpose: The main purpose of the study was to apply a new MCDM model for pallet truck selection in the textile workshop.

Study design/methodology/approach: This article presents a simplified adoption of the Simple Weighted Sum Product (WISP) method, the Simplified WISP (WISP-S) method. The proposed method has fewer computation steps than the regular WISP method. In addition, this study proposes a new hybrid MCDM model in the literature by combining the MEREC method and the WISP-S method.

Finding/conclusions: The obtained results can be achieved in a shorter time compared to regular WISP. The application of the new method is considered in this study. In order to check whether the WISP-S method achieves accurate results, the results of the WISP-S method and the results of the ROV and WASPAS methods were compared. As a result of the comparison of the results of the methods, it was observed that the WISP-S method achieved accurate results.

Limitations/future research: As a direction for future research, other MCDM models can be applied for solving the same problem. When it comes to the limitations of the proposed model, it can be mentioned that the MCDM model is based on the use of crisp numbers.

Keywords
WISP-S, MEREC, pallet truck, logistics

Introduction

In many research areas, the use of multiple criteria decision-making (MCDM) methods for solving many various decision-making problems, is still an topica research subject (Veličkovska, 2022; Stanujkic, Karabasevic, & Popovic, 2021; Popović, Popović, & Karabašević 2021;

Mukhametzyanov, 2021; Shadrina & Ikatrinasari, 2021; Karabasevic, Radanov, Stanujkic, Popovic, & Predic 2021; Jauković-Jocić, Karabašević, & Jocić, 2020). As a result of previous research, many well-known MCDM methods have been proposed, such as the SAW method (MacCrimon, 1968), AHP method (Saaty, 1977), TOPSIS (Hwang & Yoon, 1981), VIKOR method (Opricovic, 1998), MULTIMOORA method (Brauers & Zavadskas, 2010)

In addition, some new MCDM methods have also been proposed, such as ARAS method (Zavadskas & Turskis, 2010), WASPAS (Zavadskas, Turskis, Antucheviciene, & Zakarevicius, 2012), EDAS method (Keshavarz Ghorabaee, Zavadskas, Olfat, & Turskis, 2015), MABAC (Pamučar & Ćirović, 2015), CODAS method (Keshavarz Ghorabaee, Zavadskas, Turskis, & Antucheviciene 2016), PIPRECIA method (Stanujkic, Zavadskas, Karabasevic, Smarandache, & Turskis, 2017), SECA method (Keshavarz-Ghorabaee, Amiri, Zavadskas, Turskis, & Antucheviciene, 2018), FUCOM method (Pamuča, Stević, & Sremac, 2018), CoCoSo method (Yazdani, Zarate, Zavadskas, & Turskis, 2019), PIPRECIA-S (Stanujkic, Karabasevic, Popovic, & Sava, 2021) and the MULTIMOOSRAL method (Ulutaş et al., 2021).

Finally, Stanujkic, Popovic, Karabasevic, Meidute-Kavaliauskiene and Ulutaş (2021) developed a new MCDM method called Simple Weighted Sum-Product (WISP) method combining some approaches implemented in the ARAS, WASPAS, CoCoSo, and MULTIMOORA methods. The Simple WISP method uses four utility measures to determine the overall utility of the alternative. In this article, the possibility of using the WISP-S method based on the usage of two utility measures is considered. Thus, results can be achieved in a shorter time compared to regular WISP.

MCDM methods have been used to solve many different decision-making problems, such as e-Learning website selection (Khan, Ansari, Siddiquee, & Khan, 2019), warehouse location selection (Ocampo et al., 2020), motorcycle selection (Özdağoğlu, Keleş, Altınata, & Ulutaş, 2021), personnel selection (Popović, 2021), hotel selection (Peng, Wang, & Wang, 2021), and pandemic hospital site selection (Boyacı & Şişman, 2022). In this study, the pallet truck, which is one of the Material Handling Equipment, will be selected. In the literature, MCDM methods have been used for the selection of material handling equipment. Pamučar and Ćirović (2015) selected forklifts with DEMATEL and MABAC methods. Sarıçalı and Kundakçı (2017) selected forklifts with the KEMIRA-M method. Fazlollahtabar, Smailbašić and Stević (2019) made a forklift selection for a warehouse with the FUCOM method. Ulutas et al. (2020) made stacker selection with CCSD, ITARA, and MARCOS methods. Vesković, Stević, Nunić, Milinković, and Mladenović (2022) selected the reach stacker using Fuzzy FUCOM and Fuzzy MARCOS methods.

The application of the WISP-S method was carried out in a textile workshop. Since the MEREC method is a very new method, it has been used in very few publications in the literature. In this study, the MEREC method will be used to obtain criteria weights. This study makes two contributions to the literature. First, a new MCDM method will be introduced to the literature. Secondly, a new hybrid MCDM model consisting of MEREC and WISP-S methods will be presented to the literature. In this study, the application possibilities of the proposed WISP-S method are demonstrated on the example of pallet truck selection process.

Therefore, this article is organized as follows. In Section 1, the methodologies of MEREC and WISP-S method are presented in detail. Section 1 presents the application of the proposed model. Finally, a conclusion is presented.

1. Preliminaries

1.1. MEREC method

The steps of the MEREC method are described below (Ghorabaee, Amiri, Zavadskas, Turskis, & Antucheviciene 2021; Ghorabaee, 2021).

Step 1. A decision matrix is arranged. The decision matrix is presented below.

$$X = \left[x_{ij}\right]_{m\times n} \tag{1}$$

Step 2. The decision matrix is normalized with Equations 2 and 3.

$$v_{ij} = \frac{x_{ij}}{\max_i x_{ij}} \quad \textit{if } j \in NB \tag{2}$$

$$v_{ij} = \frac{\min_i x_{ij}}{x_{ij}} \quad \textit{if } j \in B \tag{3}$$

B and NB are shown in the equations mean Beneficial and Non-Beneficial, respectively.

Step 3. The overall performance (T_i) of the alternatives are computed.

$$T_i = ln\left(1 + \left(\frac{1}{m}\sum_j \left|ln\ (v_{ij})\right|\right)\right) \quad (4)$$

Step 4. The performance of alternatives (T'_{ij}) are computed by removing each criterion.

$$T'_{ij} = ln\left(1 + \left(\frac{1}{m}\sum_{k,k\neq j} \left|ln\ (v_{ij})\right|\right)\right) \quad (5)$$

Step 5. The summation of absolute deviations (Y_j) are obtained as follows.

$$Y_j = \sum_i \left|T'_{ij} - T_i\right| \quad (6)$$

Step 6. The weights (w_j) of criteria are computed with Equation 7.

$$w_j = \frac{Y_j}{\sum_k Y_k} \quad (7)$$

1.2. The Simplified WISP (WISP-S) Method

The basic intention of the WISP-S method is to use two instead of four utility measures. Therefore, the calculation procedure of the WISP-S method can be represented by applying the following steps:

Step 1. A decision-making matrix, which is shown in Eq.1, is constructed.

Step 2. A normalized matrix with Equation 8 is constructed.

$$r_{ij} = \frac{x_{ij}}{\max_i x_{ij}} \quad (8)$$

Step 3. Two utility measures (u_i^{sd} and u_i^{pr}) are computed as follows.

$$u_i^{sd} = \sum_{j\in\Omega_{\max}} r_{ij}w_j - \sum_{j\in\Omega_{\min}} r_{ij}w_j \quad (9)$$

$$u_i^{pr} = \frac{\prod_{j\in\Omega_{\max}} r_{ij}w_j}{\prod_{j\in\Omega_{\min}} r_{ij}w_j} \quad (10)$$

where: u_i^{sd} shows differences between the weighted sum of normalized ratings, and u_i^{pr} denotes ratios between a weighted product of normalized ratings of alternative i, respectively.

Step 4. Two utility measures are recalculated as follows.

$$\bar{u}_i^{sd} = \frac{1+u_i^{sd}}{1+max_i\, u_i^{sd}} \quad (11)$$

$$\bar{u}_i^{pr} = \frac{1+u_i^{pr}}{1+max_i\, u_i^{pr}} \quad (12)$$

where: $\bar{u}_i^{sd}$ and $\bar{u}_i^{pr}$ denote recalculated values of u_i^{sd} and u_i^{pr}.

Step 5. The overall utility u_i of each alternative is calculated with Equation 13.

$$u_i = \frac{1}{2}(\bar{u}_i^{sd} + \bar{u}_i^{pr}) \quad (13)$$

Step 6. The alternatives are sorted. The alternative having the highest utility (u_i) is the most suitable one.

2. Application

The application of the proposed method is carried out in a textile workshop. The textile workshop would like to buy two manual pallet trucks (PT) to take the products they make to the warehouses. The owner of the workshop has determined 6 PT brands for this selection problem and has determined 7 criteria for the selection of these PT alternatives. The criteria used in the evaluation are Lifting Capacity (LC) (kilogram), Price (P) (Turkish Liras), Warrant Period (WP) (Months), Fork Length (FL) (millimeter), Maximum Fork Height (MFH) (millimeter), Brand Reliability (BR), and Ease of Finding Spare Parts (EFSP). The first 5 criteria were taken from an organization that sells pallet trucks. The owner of the workshop scored the other two criteria (BR and EFSP) between 1(Lowest)-9 (Highest). Only 2 of the 7 criteria used in the evaluation were determined as non-beneficial criteria. Non-beneficial criteria are P and FL. The decision matrix is shown in Table 1.

The matrix is normalized by applying Equations 2 and 3 to the matrix shown in Table 1. The normalized matrix is presented in Table 2.

Table 1 Decision Matrix

Pallet Trucks \ Criteria	LC	P	WP	FL	MFH	BR	EFSP
PT 1	2500	6150	18	1150	200	5	7
PT 2	2500	7400	18	1150	195	8	7
PT 3	2000	7250	12	800	190	5	8
PT 4	2000	5750	24	1100	200	7	8
PT 5	3000	7600	18	1150	190	7	7
PT 6	3000	8400	24	1100	200	5	8

Source: the authors' calculations

Table 2 Normalized Decision Matrix (MEREC)

Pallet Trucks \ Criteria	LC	P	WP	FL	MFH	BR	EFSP
PT 1	0.800	0.732	0.667	1	0.950	1	1
PT 2	0.800	0.881	0.667	1	0.974	0.625	1
PT 3	1	0.863	1	0.696	1	1	0.875
PT 4	1	0.685	0.500	0.957	0.950	0.714	0.875
PT 5	0.667	0.905	0.667	1	1	0.714	1
PT 6	0.667	1	0.500	0.957	0.950	1	0.875

Source: the authors' calculations

With Equation 4, T_i values are found. Table 3 presents these values.

Table 3 T_i Values

Pallet Trucks	T_i
PT 1	0.153
PT 2	0.189
PT 3	0.102
PT 4	0.241
PT 5	0.189
PT 6	0.200

Source: the authors' calculations

T'_{ij} values are obtained by using Equation 5. These values are presented in Table 4.

Table 4 T'_{ij} Values

Pallet Trucks \ Criteria	LC	P	WP	FL	MFH	BR	EFSP
PT 1	0.120	0.107	0.093	0.153	0.146	0.153	0.153
PT 2	0.158	0.172	0.132	0.189	0.186	0.122	0.189
PT 3	0.102	0.079	0.102	0.046	0.102	0.102	0.082
PT 4	0.241	0.190	0.146	0.235	0.235	0.196	0.224
PT 5	0.131	0.175	0.131	0.189	0.189	0.141	0.189
PT 6	0.143	0.200	0.100	0.194	0.193	0.200	0.181

Source: the authors' calculations

With Equations 6 and 7, Y_j values and weights (w_j) of the criteria are found. The results of the MEREC method are shown in Table 5.

Table 5 The Results of MEREC

Criteria / Results	LC	P	WP	FL	MFH	BR	EFSP
Y_j	0.179	0.151	0.370	0.068	0.023	0,160	0.056
w_j	0.178	0.150	0.367	0.068	0.023	0.159	0.056

Source: the authors' calculations

After finding the weights of the criteria, the proposed WISP-S method is used. With Equation 8, the decision matrix is normalized. Table 6 presents the normalized decision matrix.

Table 6 Normalized Decision Matrix (WISP-S)

Criteria / Pallet Trucks	LC	P	WP	FL	MFH	BR	EFSP
PT 1	0.833	0.732	0.750	1	1	0.625	0.875
PT 2	0.833	0.881	0.750	1	0.975	1	0.875
PT 3	0.667	0.863	0.500	0.696	0.950	0.625	1
PT 4	0.667	0.685	1	0.957	1	0.875	1
PT 5	1	0.905	0.750	1	0.950	0.875	0.875
PT 6	1	1	1	0.957	1	0.625	1

Source: the authors' calculations

After the normalization processes, Equations 9-13 are applied to obtain the results of the WISP-S method, which are indicated in Table 7.

Table 7 The Results of WISP-S

Results / Pallet Trucks	u_i^{sd}	u_i^{pr}	$\bar{u}_i^{sd}$	$\bar{u}_i^{pr}$	u_i	Rankings
PT 1	0.417	0.000612184	0.923	0.999445135	0.961	5
PT 2	0.454	0.000793491	0.947	0.999626230	0.973	4
PT 3	0.302	0.000432393	0.848	0.999265553	0.924	6
PT 4	0.536	0.001167697	1	1	1	1
PT 5	0.459	0.000790590	0.950	0.999623333	0.975	3
PT 6	0.508	0.000856578	0.982	0.999689244	0.991	2

Source: the authors' calculations

ROV and WASPAS methods were applied to the decision matrix shown in Table 1 to check whether the WISP-S method achieved correct results. The results of the ROV and WASPAS methods and the results of the WISP-S method are shown in Table 8. According to the results of the WISP-S method, pallet trucks are listed as follows; PT4, PT6, PT5, PT2, PT1, and PT3.

Table 8 The Results of methods

Methods / Pallet Trucks	WISP-S	ROV	WASPAS
PT 1	5	5	5
PT 2	4	4	4
PT 3	6	6	6
PT 4	1	1	1
PT 5	3	3	3
PT 6	2	2	2

Source: the authors' calculations

As can be seen from Table 8, the results of all three methods are the same. As a result, it is seen that the WISP-S method achieves accurate results.

Conclusion

This article considers a simplification of the Simple WISP method, the WISP-S method. Compared to the Simple WISP method, which uses four utility measures to determine the overall utility of an alternative, the WISP-S method uses only two utility measures which express the difference and the ratio between the sum of weight-normalized ratings of beneficial and non-beneficial criteria of each alternative.

The application of the WISP-S method was demonstrated in the pallet selection problem of a textile workshop. According to the results of the WISP-S method, pallet trucks are listed as follows; PT4, PT6, PT5, PT2, PT1, and PT3. ROV and

WASPAS methods were used to check whether the newly developed WISP-S method reached accurate results. The results of the ROV and WASPAS methods and the results of the WISP-S method were the same. Therefore, it has been proven that the WISP-S method achieves accurate results. This study makes two contributions to the literature. First, a new MCDM method has been developed. Secondly, a new hybrid MCDM model consisting of MEREC and WISP-S methods has been introduced to the literature. Future studies may develop fuzzy and grey extensions of the WISP-S method.

As a direction for future research, other MCDM-based models can be applied for solving the pallet truck selection problem. When it comes to the limitations of the proposed model, it can be mentioned that the MCDM model (MEREC-WISP-S) is based on the use of crisp numbers.

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